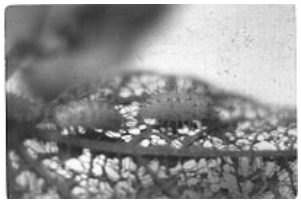
Biological Control of the Mexican Bean Beetle *Epilachna varivestis* (Coleoptera: Coccinellidae) Using the Parasitic Wasp *Pediobius foveolatus* (Hymenoptera: Eulophidae)

2002


Mexican bean beetle larvae


P. foveolatus

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SCOPE AND COVERAGE

In 2002, the Mexican bean beetle (MBB) *Epilachna varivestis* (Coleoptera: Coccinellidae) (Figure 1.) biological control program involved 35 growers with 96 nurse plots. This was an increase of one grower and seven plots from 2001. Planting began on May 6 with the last plot planted on May 22, well before the Memorial Day target date. This insures that the snap beans germinate in sufficient time to attract the overwintering MBB adults. All nurse plots were treated at planting with the preemergence herbicides Pursuit and Dual at Rutgers recommended rates.

RELEASE SCHEDULE AND NURSE PLOT MONITORING

One-eighth acre nurse plots are planted in areas adjacent to soybean fields with a mixture of 15 lbs. of snap beans and 5 lbs. of soybeans before the grower plants (Figure 1). The snap beans germinate first and attract any MBB adults in the area to the nurse plot (Figure 3). The only existing food source for the MBB at that time is the snap beans with the beetles preferring snap beans over soybeans. Once the snap beans are consumed, the later germinating soybeans keep the beetles in the plot and out of the farmer's field. The New Jersey Department of Agriculture, Phillip Alampi Beneficial Insect Laboratory (PABIL) uses the nurse plots as a trap crop to lure in the MBB and keep them in the plot. Once this is accomplished, the parasitoid *Pediobius foveolatus* (Hymenoptera: Eulophidae) is released into the plot. The early releases allow for rapid buildup of parasites within the nurse plots. Although *P. foveolatus* females prefer third and fourth instar larvae they attack all instars or larval stages of the Mexican bean beetle and oviposit an average of 25 eggs within each larva. The parasitized larvae eventually die forming dark brown "mummies"(Figure 4). *P. foveolatus* is a gregarious parasite with an average of 25 wasps, of which approximately 75% are female, emerging from each mummy. The emerging wasps attack any new larvae in the nurse plot and continue to search for and parasitize any healthy MBB larvae, which may have migrated from the nurse plot into the farmer's soybean field.

Figure 1. Planting nurse plot

Figure 2. Nurse plot

P. foveolatus releases are based on initial egg sighting (**egg release**) and larval counts (**trigger release**). Since 1985 egg releases have consisted of a total of 6,000 parasites with the first partial release of 3,000 *P. foveolatus* made at the first observation of a Mexican bean beetle (MBB) egg cluster. The second partial egg release of 3,000 parasites is made two to three days later; Trigger releases resulted when larvae were observed. The initial trigger release was divided into two releases, two to three days apart. If the MBB larval count increased seven days after the initial trigger release, then a second single trigger release was made.

Release decisions were based on monitoring the nurse plots two times per week; the sampling unit within each plot consisted of 125 plants with 25 plants examined in each of five locations where MBB feeding is observed.

Figure 3. Mexican bean beetle adult and egg mass

Figure 4. Parasitized larvae

MBB LEVELS, PARASITES RELEASED AND PARASITISM

Mummies are parasitized larvae. The peak percent parasitism in the nurse plots averaged 20.6% (Table 1). Of the plots where releases were made, 40.6% required the egg release as compared to 23.5% of the plots last year. Trigger releases were required in 36.5% of the plots versus 52.8% of the plots in 2001. A total of 544,000 parasites were released into the nurse plots with an average of 5,975 per plot. Populations of MBB developed in 77% of the nurse plots compared to 76.4%, 64%, 83.3%, 73.1%, and 86.7%, for the five preceding years (Tables 1 and 4). Releases were made in 74 of the 96 nurse plots (Table 1).

Historically, from the time the program was implemented in 1980, until 1991, Cumberland County has had the greatest MBB pressure but in 1991 Salem County developed the highest populations and continued to have the highest populations into 1997. Since 1998 Monmouth County has had the highest MBB populations. There was slight increase in activity in Gloucester County in 2002, as compared to 2001. The MBB populations remained stable in all of the other counties in 2002 when one looks at the number of *Pediobius foveolatus* released (Table 2). An encouraging sign is that although the MBB population in Gloucester County has increased slightly, the parasitism rate has increased within the County, so the MBB population is still under control. The data indicate that the populations of MBB have declined and then stabilized at a lower level.

DIRECT FIELD RELEASES

In 2002, as in past years, field releases of surplus parasites were made to keep additional pressure on the MBB population (Table 3). The surplus parasites come about in the course of production where a minimum number of parasites are needed to meet possible demand in the nurse plots. If the numbers required in the plots are less than what was produced that week, a surplus results. Instead of letting the parasites die in the laboratory, they are shipped to the field where they can do some good. Field releases are made in mid to late season wherever MBB are observed and consist of parasites that have not been used in the nurse plot program and a system developed to utilize parasites that would otherwise be held in the lab and would eventually die. There is no correlation between the MBB population and the number of parasites released. Field releases are made directly into soybean, snapbean and lima bean fields throughout Central and Southern New Jersey. There were 62 direct field releases totaling 1,080,000 parasites which represents a

increase from 2001 when 970,000 parasites were released throughout the state. The bulk of the releases were made in Salem County with 350,000 parasites released. The next highest county was Cumberland with 230,000. Including the number of parasites released in the nurse plots, a total of 1,624,000 parasites were released statewide. The number of parasites released in direct field releases depends on the number of *P. foveolatus* available and is not linked to a decision table, as are trigger releases in the nurse plots. The field releases consist of extra parasites from the reserve stock for the nurse plots and if the parasites are not needed in the nurse plots they are put into fields wherever MBB are found. The purpose of the field releases is threefold: 1) to get the parasites out where they can do some good rather than storing them in the laboratory where they will eventually die 2) to control the MBB in areas where it could attain high population levels and 3) to reduce the over wintering population of MBB to lessen the economic impact to the farmers in subsequent years.

DISCUSSION

The last few years the county with the greatest MBB pressure has been Monmouth. This year there was a slight change in that Gloucester had the highest MBB pressure. This is a change from the past years, where in the 80's and 90's Salem or Cumberland were the counties with the greatest MBB populations. The MBB populations in Gloucester increased somewhat from last season but remained below economically damaging levels and are nowhere near the level experienced in the 1980's. The highest MBB populations were in the, Swedesboro, Monroe Township area of Gloucester County.

No participating grower had to spray for Mexican bean beetle control nor was there any need for preventive applications to any of the nurse plots.

E. varivestis population levels

Populations of MBB developed in 74% of the nurse plots in Salem County, 80% in Gloucester, 77% in Cumberland, 75% in Monmouth, and 100% of the plots in Mercer. The percentage of plots requiring releases in 2002 increased slightly in the southern counties and slightly decreased in the central counties. The percentages are a rough indication of the percent of soybean acreage in that county which may have required a chemical treatment to control the MBB. Every year there are roughly 115,000 acres of soybeans planted in New Jersey. Seventy-five percent of that acreage is in the area that is susceptible to MBB damage. Hunterdon, Somerset and Warren have never developed economically damaging MBB population levels.

Figure 5 shows the "host peak" (a measure of the Mexican Bean Beetle population in the nurse plots) and the number of hosts parasitized in the nurse plots over time. The number of parasites released in the nurse plots does follow the *E. varivestis* population where more *P. foveolatus* are released in years of greater bean beetle populations and less in years with reduced populations. There have been fluctuations in *E. varivestis* numbers since 1981 and the number of *P. foveolatus* released has followed this cycle. Insect populations are cyclical and the MBB population shown in Figure 5 is no exception. The striking thing about Figure 5 is that the peak population of the MBB in the 90's is half of what it was in the 80's and the present populations

are one fourth of what they were in the 1980's. This cycle looks like it may continue into the future where the MBB population is cut in half in the following decade and is probably a direct result of the NJDA's MBB program. The increase in population figures for 1986 and 1987 in Figure 5 is due to the fact the PABIL began working in the Bivalve area of Cumberland County for the first time and that area had high populations of the MBB and had never received releases of *P. foveolatus*.

Figure 5. Mexican bean beetle Population and Parasitism 1981-2002

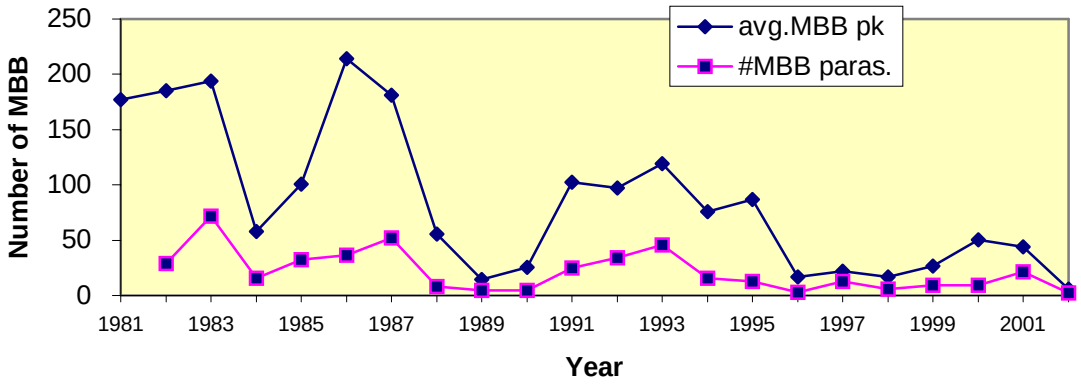

Figure 5 also shows that the population of MBB is declining in NJ. In 1984 there was a precipitous decline in the population and then a rise in succeeding years; this is also true of 1988-1990. Although the overall trend is down, Dively (1985) stated that after a decline in numbers, the MBB population may take up to three years to reach peak levels again. Figure 5 does show this effect.

Parasitism decreased in 2002 possibly due to drought and population levels of the MBB, but because the data are very variable, this may be an artifact (Table 4). Parasitism data is dependent on the scouts finding mummies; if mummies are on bean leaves that have abscised and fallen to the ground, the mummies are more difficult to find, especially for an inexperienced field scout. Therefore, parasitism data is underrepresented and the parasitism is probably greater than what is shown in Figure 5.

The main result of the program has been to reduce the second generation MBB population to levels that do not cause economic loss to the growers. The second generation of MBB is the generation of the population that causes the most injury to the beans and is the population that is treated when chemical controls are necessary.

RELEASES

In 1986 a procedural change was made where releases were initiated at egg sighting instead of releasing only when larvae were present, as was the case in prior years. The theory behind the egg releases was to get the parasites out and in the field so they are ready and waiting when

the larvae appear, enabling them to impact the first generation MBB population before the larvae have a chance to develop. Since the egg releases have been implemented, the peak MBB populations have declined from what they were in the early 1980's.

In 2000 another procedural change was made where the *P. foveolatus* were released in mummies versus releases of adults. For example, if 2000 parasites were required for a nurse plot, instead of releasing 2000 adults, 80 mummies were released in nylon screen cages. There is an average of 25 parasites per mummy so the equivalent number of parasites was released. This change in procedure allowed the PABIL to increase efficiency and to release the requisite number of parasites using fewer personnel. No loss of efficacy was noted in the field so future releases will be mummy releases.

The anecdotal evidence from observations by the field staff supports the idea that the overwintering populations are reduced in areas where nurse plots are present but MBB population increases still occur (Figure 5). The evidence is that all counties but Salem have not had seriously high MBB populations since the mid-1980's. Salem's increase was possibly due to flights of MBB from neighboring states and the fact that some growers retired from farming and left the program. The nurse plots on their property were not replaced until some years later. The increase in MBB populations in 1990 to 1993 in Figure 5 is almost all due to Salem County. Monmouth County's numbers are higher over the past several years but are not due to migrations from other states as they were for the increases in Salem. Figure 5 also shows that the MBB population levels are not as high in the new decade as they were in the 1990's or 1980's when the program started. This can be considered as evidence that the releases by the PABIL have decreased the MBB population in the state. The peak populations are no longer as great as they were. Dively (1985) stated that the MBB population levels are more dependent on weather and the biology of the insect rather than *P. foveolatus* and that the MBB possesses great potential to bounce back within three years as was seen in the Battlefield area of Monmouth County where a "hot-spot" developed. The release of *P. foveolatus* has kept the MBB population below economic levels and as long as the MBB program is continued, growers in New Jersey should not have serious problems with the MBB.

COST CONSIDERATIONS

In the last six years there has been an average of 115,000 acres of soybeans planted in New Jersey. Seventy-five percent of that acreage is in the area that is susceptible to MBB damage. Hunterdon, Somerset and Warren have never developed much MBB pressure. The cost of chemical control for one acre of soybeans (one application) has been estimated to be around $17.00 per acre including the cost of the insecticide, equipment and grower time in the field (J. Mahar, Rutgers ICM, personal communication). Approximately 86,250 acres are in the area susceptible to MBB attack. If a MBB population develops on 50% of that acreage and if 25% of it requires treatment, then the cost for treatment would be $366,562.50. If 90% of the acreage requires treatment then the cost of control would $1,319,625.00. Using *P. foveolatus* has resulted in substantial savings to the growers in reduced insecticide costs since 1981.

SUMMARY AND CONCLUSION

Overall this was a successful year and the populations of the MBB may have increased slightly in Gloucester and Cumberland Counties, but overall releases of parasites per plot is down.

A portion of the soybean check-off funds reserved for research has been allocated to the NJDA and is used to offset some of the costs for field implementation of the biological control program. In New Jersey, populations of bean beetles are kept down below economically damaging levels in areas where there are nurse plots but also protect other soybean and bean fields in the same regions as the nurse plots due to parasite dispersal. There is no economic injury to the growers from the more damaging second-generation MBB population. Even though a grower may not have any nurse plots adjacent to his fields, that grower still benefits because the plots are located so that the majority of areas in the state are protected by the parasites.

E. varivestis has a great potential to bounce back and become a problem again but should be kept from economically damaging levels as long as the Phillip Alampi Beneficial Insect Laboratory can maintain its nurse plot and parasite release program.

2003 PLANS

Plans for the upcoming season are to keep the pressure on the MBB populations in Gloucester, Cumberland and Monmouth Counties by maintaining the number of plots in those hot spot areas. The number of plots in the rest of the state will decrease due to the overall decline in MBB populations. Should the MBB populations increase in the future, the number of plots will be increased in those areas of higher MBB levels. Mummy releases worked well and will continue in 2003.

REFERENCES

1985. Dively, G.P. Mexican Bean Beetle Biological control Demonstration Project: 1980-1983. Conducted By The State Departments of Agriculture in Delaware, Maryland, New Jersey, and Virginia in Cooperation with the USDA-APHIS-PPQ National Biological Control Program.

TABLE 1. NURSE PLOT SUMMARY BY COUNTY 2002

County	Total No. of Plots	Total No. of Parasites Released	Average No. of *P. foveolatus* Released per Plot	No. of Plots with *P. foveolatus* Releases	Percent of Plots with *P. foveolatus* Releases	Average Percent Parasitism	No. of Plots with Egg Releases Only	No. of Plots with Trigger Releases
BURLINGTON	7	40000	5714	5	71	2.1	2	3
CUMBERLAND	27	140000	5185	21	77	25.9	14	7
GLOUCESTER	15	96000	6400	12	80	19.7	7	5
MERCER	4	30000	7500	4	100	10.7	1	3
MONMOUTH	20	108000	5400	15	75	24.5	7	8
SALEM	23	130000	5652	17	74	40.8	8	9
TOTAL	96	544000		74	77		39	35
AVG. LEVELS			5975			20.6		

TABLE 2. NURSE PLOT SUMMARY BY YEAR/COUNTY

County/ Year	Total No. of Plots	Total No. of Parasites Released	Average No. of *P. foveolatus* Released per Plot	No. of Plots with *P. foveolatus* Releases	Percent of Plots with *P. foveolatus* Releases	Average Percent Parasitism	No. of Plots with Egg Releases Only	No. of Plots with Trigger Releases
CUMBERLAND								
2002	27	140000	5185	21	77	25.9	14	7
2001	25	118000	4720	16	64	72.9	5	11
2000	23	84000	3652	12	52.1	51.4	6	6
1999	29	128000	4413	21	72.4	21.1	13	8
1998	33	144000	4363	20	60.6	12	8	12
1997	34	242000	7143	28	82.4	61.5	3	25
1996	29	118000	4069	13	44.8	18.3	3	10
1995	33	100000	3030	20	60.6	5.7	13	7
1994	39	30000	769	5	12.8	0.0	5	0
1993	46	250000	5435	35	76.1	20.6	20	2
1992	51	500000	9804	45	88.3	54.3	27	9
1991	45	276000	6133	34	75.6	19.9	16	7
1990	51	250000	4902	29	57.0	47.0	9	5
1989	64	78000	1219	13	20.3	16.1	13	0
1988	63	264000	4190	35	55.5	9.9	32	3
1987	60	622000	10366	57	95.0	18.2	21	36
1986	59	940000	15932	57	96.6	41.5	18	19
BURLINGTON								
2002	7	40000	5714	5	71	2.1	2	3
2001	6	32000	5333	6	100	71.9	5	1

2000	8	48000	6000	6	75.0	4.5	1	5
1999	5	22000	4400	3	60.0	6.5	1	2
1998	3	30000	10000	3	100	24.7	1	2
1997	2	18000	9000	2	100.0	70.5	0	2
1996	1	8000	8000	1	100.0	53.0	0	1
1995	3	24000	8000	3	100.0	59.6	0	3
1994	none							
1993	none							
1992	4	42000	10500	4	100.0	40.7	0	2
1991	3	26000	8667	2	66.7	28.9	0	2
1990	1	8000	8000	1	100.0	0.0	0	0
1989	2	12000	6000	2	100.0	56.5	2	0
1988	none							
1987	1	10000	10000	1	100.0	0.0	0	1
1986	none							

GLOUCESTER

2002	15	96000	6400	12	80	19.7	7	5
2001	8	62000	7750	8	100	15.2	1	7
2000	11	66000	6000	9	81.1	9.3	4	4
1999	10	58000	5800	8	80.0	13.6	3	5
1998	12	70000	5833	9	75	25.1	1	8
1997	13	86000	6615	13	92.3	26.4	4	8
1996	16	88000	5500	12	75.0	14.8	8	4
1995	13	58000	4462	8	61.5	34.0	3	5
1994	13	60000	4615	8	61.5	34.0	3	5
1993	21	266000	12667	20	95.2	42.8	3	16
1992	10	72000	7200	9	90.0	13.3	3	1
1991	12	142000	11833	12	100.0	12.9	2	4
1990	13	92000	7077	12	92.0	23.0	4	1
1989	17	84000	4941	14	82.4	13.7	14	0
1988	12	36000	3000	6	50.0	22.7	6	0
1987	13	158000	12153	12	92.3	29.7	4	8
1986	10	64000	6400	10	100.0	9.6	9	1

MERCER

2002	4	30000	7500	4	100	10.7	1	3
2001	3	22000	7333	3	100	46.6	1	2
2000	3	8000	2666	1	33.3	0.0	0	1
1999	3	16000	5333	2	66.6	16.9	0	2
1998	6	44000	7333	5	83.3	17.7	0	18
1997	9	72000	8000	8	88.9	43.8	0	8
1996	9	70000	7778	9	100.0	21.2	1	8
1995	10	62000	6200	7	70.0	38.7	1	5
1994	11	68000	6182	10	90.9	1.2	7	3
1993	6	52000	8667	6	100.0	2.6	0	2
1992	7	56000	8000	7	100.0	32.4	3	1

1991	9	50000	5556	8	88.9	12.5	1	2
1990	9	38000	4222	5	56.0	5.0	1	0
1989	9	12000	1333	2	22.2	0.0	2	0
1988	2	12000	6000	2	100.0	0.0	2	0
1987	6	30000	5000	5	83.3	72.2	5	0
1986	9	64000	7111	7	77.7	15.6	5	0
MONMOUTH								
2002	20	108000	5400	15	75	24.5	7	8
2001	17	214000	12588	17	100	45.2	2	15
2000	15	144000	9600	15	100.0	14.6	1	14
1999	20	302000	15100	19	95.0	44.3	1	18
1998	18	218000	12111	18	100	38.2	0	18
1997	16	178000	11333	15	93.8	61.5	1	14
1996	12	86000	7167	11	91.7	12.1	2	8
1995	11	66000	6000	9	81.8	38.0	1	5
1994	13	74000	5692	10	76.9	4.4	3	7
1993	12	126000	10500	12	100.0	18.7	1	10
1992	12	106000	8833	12	100.0	10.8	4	3
1991	14	86000	6143	11	78.6	26.7	3	4
1990	23	102000	4435	13	57.0	9.0	1	0
1989	27	160000	5926	23	85.2	13.6	19	4
1988	29	272000	9379	25	86.2	21.1	17	7
1987	25	310000	12400	25	100.0	26.5	8	12
1986	23	379000	16478	21	91.3	23.1	8	8
SALEM								
2002	23	130000	5652	17	74	40.8	8	9
2001	30	130000	4333	18	60	44.6	7	11
2000	30	170000	5666	21	72.4	31.7	4	17
1999	29	184000	6344	27	93.1	47.9	16	11
1998	36	174000	4833	24	66.7	19.5	9	15
1997	39	238000	6103	33	84.6	18.0	21	12
1996	41	300000	7317	30	73.2	1.7	10	20
1995	50	518000	10360	39	70.0	35.0	7	32
1994	44	618000	11405	39	88.6	21.8	5	28
1993	26	422000	16230	26	100.0	42.9	2	15
1992	28	496000	32643	28	100.0	38.0	2	10
1991	17	420000	24706	17	100.0	35.6	1	15
1990	10	138000	13800	10	100.0	23.0	2	3
1989	11	78000	7091	9	81.8	16.1	4	4
1988	11	74000	6727	7	63.6	19.5	5	2
1987	12	130000	10833	10	83.3	25.9	1	9
1986	14	84000	6000	12	85.7	10.3	9	3

TABLE 3. SUMMARY OF ALL RELEASES IN 2002

	FIELD RELEASES		NURSE PLOT RELEASES		
County	#Field Releases	*#P. foveolatus* Released	Number of Nurse Plots	*#P. foveolatus* Released in Nurse Plots	Total *#P. foveolatus* Released
Burlington	1	20,000	7	40,000	60,000
Camden	3	30,000	0	0	30,000
Cape May	8	130,000	0	0	130,000
Cumberland	11	230,000	27	140,000	370,000
Gloucester	11	190,000	15	96,000	286,000
Mercer	1	10,000	4	30,000	40,000
Middlesex	2	20,000	0	0	20,000
Monmouth	4	50,000	20	108,000	158,000
Ocean	3	40,000	0	0	40,000
Salem	17	350,000	23	130,000	480,000
Somerset	1	10,000	0	0	10,000
TOTAL	62	1,080,000	96	544,000	1,624,000

Total Parasites Released Statewide including nurse plots= 1,624,000

TABLE 4. NURSE PLOT SUMMARY BY YEAR

Year	Total No. of Plots	Total No. of Parasites Released	Average No. of *P. foveolatus* Released per Plot	No. of Plots with *P. foveolatus* Releases	Percent of Plots with *P. foveolatus* Releases	Average Percent Parasitism	No. of Plots with Egg Releases Only	No. of Plots with Trigger Releases
2002	96	544000	5975	74	77	20.6	39	35
2001	89	578000	7009	68	76.4	49.4	21	47
2000	90	520000	5778	64	69	26.4	16	47
1999	96	710000	7395	80	83.3	25.1	34	46
1998	108	680000	6296	79	73.1	22.9	19	60
1997	113	834000	7381	98	86.7	41.7	29	69
1996	109	670000	6204	79	72	11.2	24	49
1995	120	828000	6900	86	71.6	35.2	17	57
1994	120	850000	7083	72	60	17.2	22	27

1993	111	1101600	9924	99	89.2	28.9	26	41
1992	112	1272000	11357	106	95	36.9	39	25
1991	100	1000000	10000	84	84	22.8	23	31
1990	106	628000	5925	70	66	17.7	16	9
1989	130	424000	3240	63	48.1	33.8	54	8
1988	118	682000	8883	76	64.4	14.2	62	10
1987	117	1,260,000	10125	110	94.0	28.7	39	64
1986	117	1,541,000	9487	108	92.3	17.1	49	32
1985	111	1,156,500	9973			32.3		
1984	108	633000	6806			27.1		
1983	139	975000	8705			37.1		